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REPORT NO. 564

SUSCEPTIBILITY OF STAPEDECTOMIZED PATIENTS TO NOISE INDUCED TEMPORARY THRESHOLD SHIFTS

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ABSTRACT

SUSCEPTIBILITY OF STAPEDECTOMIZED PATIENTS TO NOISE INDUCED TEMPORARY THRESHOLD SHIFTS

OBJECT

To determine whether stapedectomized patients are more susceptible to continuous noise induced temporary threshold shifts than are normal persons.

RESULTS

Stapedectomized persons did not exhibit greater susceptibility to noise induced TTS than did a normal group.

CONCLUSIONS

Additional research is necessary before a firm conclusion can be reached that the stapedectomy procedure does not enhance the susceptibility of those undergoing it to acoustic insult.

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I. INTRODUCTION

By conservative estimate there are several hundred thousand persons in the United States who have impaired hearing due to otosclerosis (1). A recent advance in the treatment of otosclerosis has been the development of the stapedectomy operation (1). A by-product of the stapedectomy procedure is that, upon completion of the operation, the patient has a severed stapedius muscle. Recent research (2-5) has shown that the reflex response of the stapedius (and perhaps the tensor tympani also) to impulse sound reduces the temporary threshold shifts (TTS) of the person exposed. However, the experiments were so designed and so conducted that they demonstrated only that the acoustic reflex (AR) could protect the individual under certain specified, artificial situations. We do not know what or if protection is afforded by the AR under normal circumstances. If we infer a protective function for the AR, we then wonder whether removal of the stapedius, as in the stapedectomy procedure, reduces the protection and enhances the susceptibility to noise induced hearing loss.

In the experiment to be described, stapedectomized patients were exposed to medium and high frequency noise of moderately high intensity. The degree of exposure used was sufficient to produce a TTS, but far below that necessary for the production of any permanent shift. The resulting TTS of those operated patients was then compared with that obtained from normal subjects exposed under comparable conditions.

II. PROCEDURE

Pre-operative reference audiograms were obtained on eight patients immediately prior to the stapedectomy. Three of the patients had the operation performed on both ears. The patients ranged in age from 20-53 years. The surgical technique was essentially that of Shea (6, 7), using vein graft and polyethylene prosthesis. The pre-exposure (post-operative) audiogram was obtained after what appeared to be adequate audiometric stabilization (from six weeks to one year post-operatively). After the audiogram had been made the patients were immediately exposed (free field) to a 1200 cps high pass filtered sound at a sound pressure level of 110-114 db for 9 to 10 minutes (see Table 1). Because of technical and administrative experimental difficulties not all patients received the same noise exposure, nor could they all be brought back and tested again. For that reason Table 1, which indicates the exposure conditions for each subject, is presented. Determination of the post-exposure threshold was so timed that the testing at 2000 cps was accomplished approximately 1 min 45 sec after termination of the noise exposure, and the testing at 4000 cps about 2 min after the end of the exposure. This timing was so arranged in order to permit comparison with the data of Glorig et al (8).

A group of persons of essentially the same age and with auditory acuity similar to that of the post-operative audiogram of the stapedectomized (experimental) patients was examined in a similar manner to determine the "normal" TTS to be expected from the noise exposure. Hereafter this group will be referred to as the control group. These controls were exposed to exactly the same conditions that their experimental counterparts had had in order to control for the differences in experimental conditions.

A block diagram of the equipment used to determine the pre- and post-exposure audiograms and to present the noise exposure to the subjects is presented in Figure 1. All testing and exposure were accomplished in an anechoic chamber. Audiometry was performed using a recently calibrated Grason-Stadler E800 Békésy type audiometer. Noise exposure was provided by feeding the output of an Allison Octave Band Equalizer through a McIntosh 60 watt amplifier into three 16 in. Universal speakers, in series, set up in a plywood reverberation chamber inside an anechoic room. Calibration of the exposure stimulus was made using a Brüel and Kjaer Audio-Spectrometer with the Brüel and Kjaer 4131 condenser microphone.

In addition to measuring TTS to noise exposure, contralateral threshold shift (CTS) measures were obtained on each subject, experimental and control, to determine the difference in CTS in normal and stapedectomized patients. The CTS was determined by having the subject track a 500 cps tone at threshold in one ear (the operated ear for the unilaterally stapedectomized patients) with the introduction of a 2400 cps high pass filtered sound at 110 db SPL in the contralateral ear to permit observation of the resulting change in threshold for the 500 cps tone. Peripheral masking should have been ruled out by use of the 500 cps tracking tone and a 2400 cps high pass filtered noise reflex activating signal. It has been suggested, however, that CTS may reflect central masking.

III. RESULTS

The post-operative results of the stapedectomies were quite satisfactory. Shown in Figure 2 for comparison are the pre- and post-operative audiogram averages for the experimental group. Also shown in Figure 2 is the average auditory acuity of the control group. Although, as previously stated, an attempt was made to match the groups for both age and, in the case of the stapedectomized patients, post-operative auditory acuity, the acuity matching was somewhat less than perfect. Presented in Figure 3 are the average TTS data for the experimental and control groups. The TTS observed in both the experimental and control groups was well within the limits suggested by Glorig et al (8). The 2 db TTS at 2 KC experienced by the experimental group, for example, was well below the limits shown by Glorig et al (8), and the 12 db shift at 4 KC by the same group was also clearly within expected limits. On the other hand, the TTS found in our control group more closely approximated that of the group on which the data of Glorig were based. The CTS obtained (Table 2) for the experimental and control groups did not differ significantly.

IV. DISCUSSION

Even though, in this experiment, we failed to find greater noise induced TTS in the stapedectomized than in the control group, they may still be more susceptible under certain conditions. There is evidence (9-11) which indicates that maximum attenuation of sound by the acoustic reflex occurs at low frequencies. It is possible that the 1200 cps high pass filtered sound did not constitute a suitable exposure to test for susceptibility to noise induced TTS because reflex action might be minimal in that frequency range. Obviously, this experiment should be repeated with a lower frequency band of noise to see if susceptibility to continuous noise (as opposed to TTS from exposure to impulse noise) is greater for that type of sound. It is planned to present such a follow-up study at a later date.

In considering the lesser TTS in the experimental group, one might also question the effect of the vein graft and polyethylene prosthesis on the results. Whatever the effect of these substitute impedance-matching devices, their influence, for practical purposes, probably is permanent. It is true that anatomical and histological changes in the vein graft (or any other substance used, as fat or gelfoam) may effect the degree of TTS, but the relative importance of this effect is questioned since the results were essentially the same for those tested six weeks post-operatively as for those tested as late as one year post-operatively.

Some explanation for the greater TTS experienced by the normals may be found in Figure 2. On that graph we note that the reference threshold acuity of the normal group is some 10-20 db better than that of the experimental group. The study of Glorig et al (8) shows that the TTS at 4 KC expected of a person with a resting threshold of 20 db is about 22.5 db, whereas the expected TTS for one with a 0 db threshold is about 27.5 db, or 5 db greater. In this experiment (Fig. 3) we found a difference in TTS at 4 KC of 13 db in the expected direction, i.e., the control group with their lower auditory threshold had the greater TTS. Purposely, no mention is made here of the stapedectomized patient's possible susceptibility to repeated impulse sound exposure. This could pose a special problem for stapedectomized patients, and there is no intent here to generalize to impulse noise from this experiment.

The CTS findings were not expected. For one thing, we had not expected to find any CTS at all in the stapedectomized patients post-operatively. Startle or distraction might possibly account for some CTS but seems a poor explanation for the amount found. Another and perhaps more likely possibility is that action of the tensor tympani muscle might be responsible for the CTS. Klockhoff (12), for one, claims that the tensor tympani cannot be acoustically-stimulated. It should be noted, however, that in a recent study by Ward (13), latencies for maximum protection by artificial elicitation of the reflex were found and the duration of these latencies was closer to that generally reported for tensor tympani (in animals) than those usually reported for the stapedius. The data from this experiment would seem more in agreement with those of Ward, cited above, and less supportive of Klockhoff.

V. SUMMARY

The susceptibility of stapedectomized and normal persons to noise induced TTS was examined. The stapedectomized group did not exhibit greater TTS after noise exposure than did the normal group. Amount of CTS shown by the two groups did not differ significantly. No good explanation could be found for this finding. It was concluded that further research was indicated before we could assume stapedectomized persons were not more susceptible to noise induced TTS than normals.

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TABLE 1

Experimental Exposure Conditions for Each Subject

Subject	SPL (in db)	Duration (Min)
1	110	10
2	110	10
3	110	10
4	110	10
5	110	10
6	110	10
7	110	10
8	114	10
9	114	10
10	114	9
11	114	9

TABLE 2

Contralateral Threshold Shifts of the Control and Stapedectomized Patients

	Average CTS (in db)
Control	8.5
Stapedectomized	6.

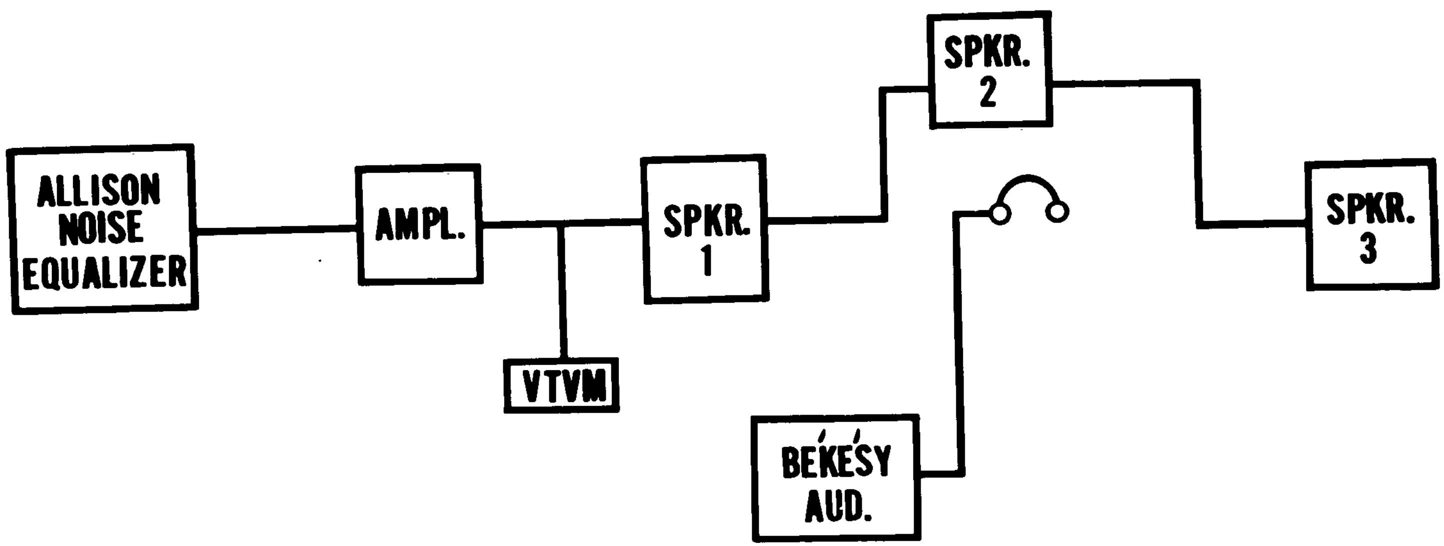

Fig. 1. Block diagram of the apparatus.

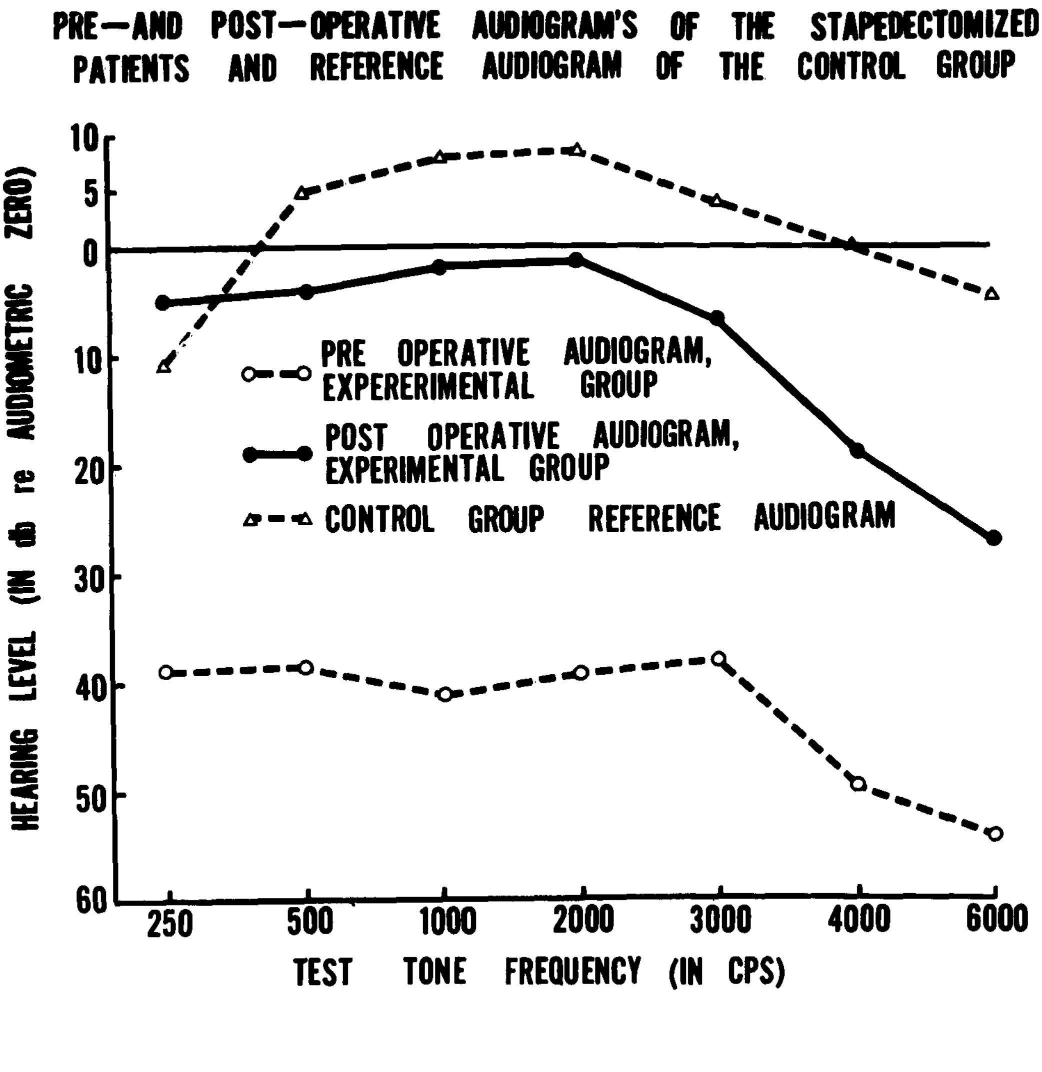

Fig. 2. Pre- and post-operative audiograms of the experimental group and audiogram of the control group.

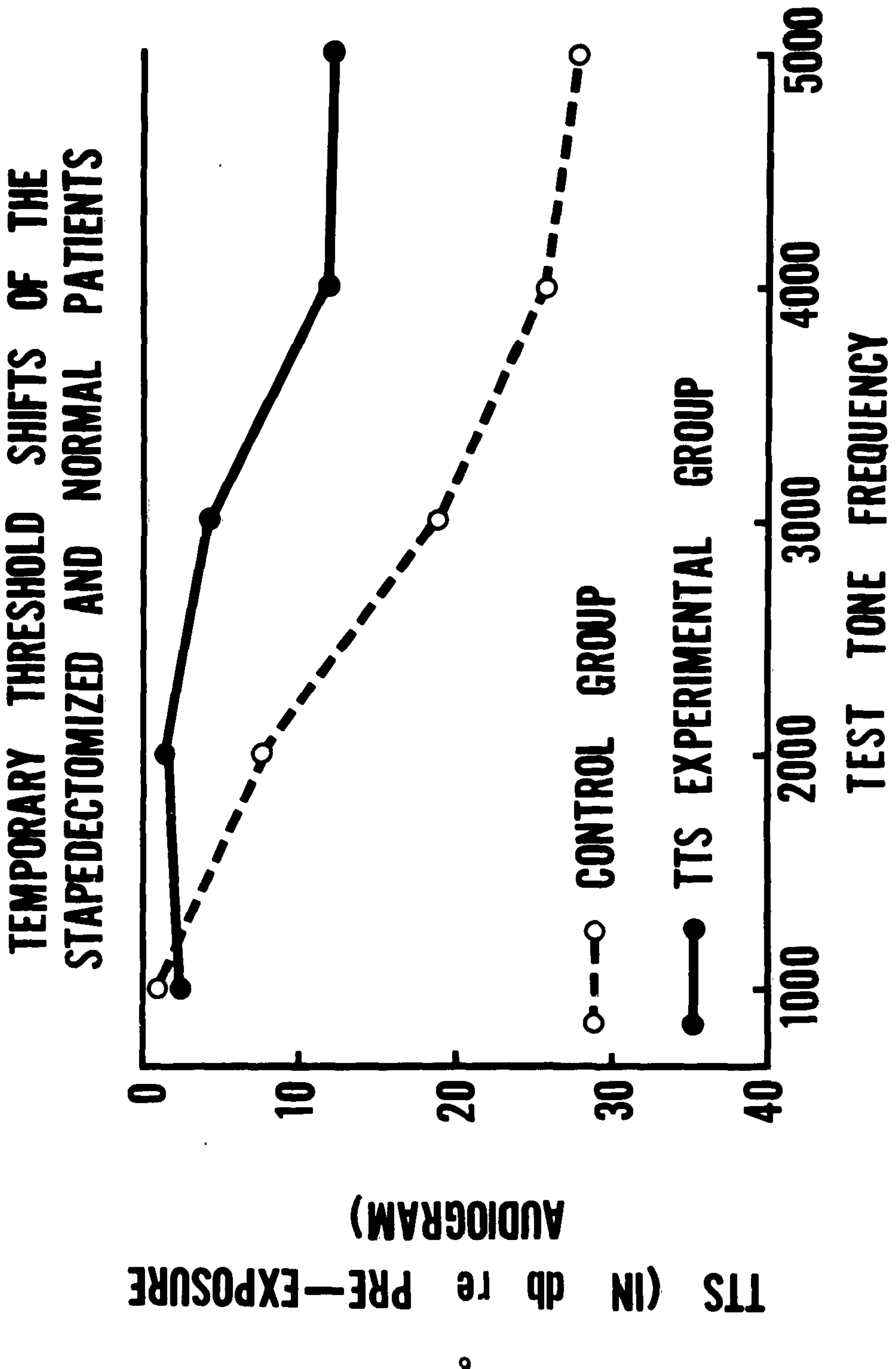

Fig. 3. Average TTS experimental and control group.

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